

Rollable Thin-Shell Nanolaminate Mirrors

Advanced concepts of actuation, control, and materials are combined.

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A class of lightweight, deployable, thin-shell, curved mirrors with built-in precise-shape-control actuators is being developed for high-resolution scientific imaging. This technology incorporates a combination of advanced design concepts in actuation and membrane optics that, heretofore, have been considered as separate innovations. These mirrors are conceived to be stowed compactly in a launch shroud and transported aboard spacecraft, then deployed in outer space to required precise shapes at much larger dimensions (diameters of the order of meters or tens of meters).

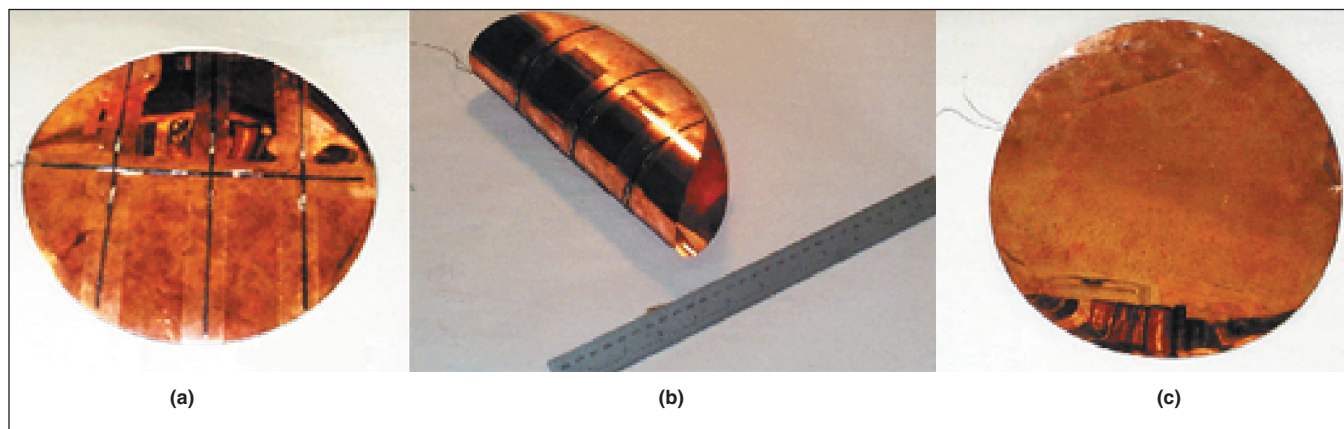
A typical shell rollable mirror structure would include (1) a flexible single- or multiple-layer face sheet that would include an integrated reflective surface layer that would constitute the mirror; (2) structural supports in the form of stiffeners made of a shape-memory alloy (SMA); and (3) piezoelectric actuators. The actuators, together with an electronic control subsystem, would imple-

ment a concept of hierarchical distributed control, in which (1) the SMA actuators would be used for global shape control and would generate the large deformations needed for the deployment process and (2) the piezoelectric actuators would generate smaller deformations and would be used primarily to effect fine local control of the shape of the mirror.

Another advanced design concept is that of nanolaminate mirror shells. This design concept builds upon technology reported previously in "Nanolaminate Mirrors With Integral Figure-Control Actuators" (NPO-30221), *NASA Tech Briefs*, Vol. 26, No. 5 (May 2002), page 80. Nanolaminates constitute a relatively new class of materials that can approach theoretical limits of stiffness and strength. For making the proposed mirrors, nanolaminates are synthesized by magnetron sputter deposition of metallic alloys and/or compounds on optically precise master surfaces to obtain an optical-quality reflector. Ideally, the

crystallographic textures of the deposited layers would be controlled to optimize mechanical performance. The present development efforts are directed toward incorporating the nanolaminate concept into the first-mentioned concept of the deployable shell structure with built-in SMA and piezoelectric shape-control actuators. In a typical intended application, a thin-shell paraboloidal mirror would be stowed by rolling it into a taco or cigar shape. Subsequently, it would be deployed by use of its SMA, which would "remember" the unrolled shape. As shown in the figure, the feasibility of this stowage/deployment concept was verified in an experiment.

This work was done by Gregory Hickey and Shyh-Shiuh Lih of Caltech and Troy Barbee, Jr., of Lawrence Livermore National Laboratory for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-30214



SMA Ribbons (a) were trained to 2-m radius of curvature and then bonded to the rear surface of a nanolaminate substrate 25 cm in diameter and 100 μm thick. The nanolaminate (b) was then rolled as though for stowage. Next, when an electric current was applied to heat the SMA ribbons, the substrate returned from the rolled-up configuration to its original 2-m radius of curvature (c).